2100 SYSTEM

Strain Gage Conditioner and Amplifier System

– Instruction Manual –

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2100 INSTRUCTION MANUAL

STRAIN GAGE CONDITIONER AND AMPLIFIER SYSTEM

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ii) subjected to misuse, negligence, or accident; or
iii) connected, installed, adjusted, or used otherwise than in accordance with the instructions furnished by us.

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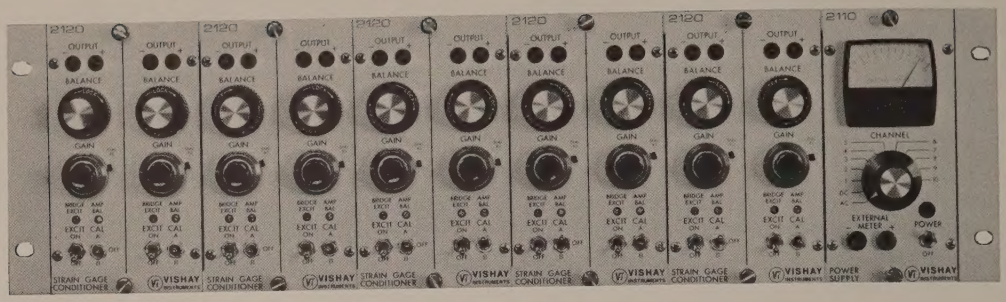
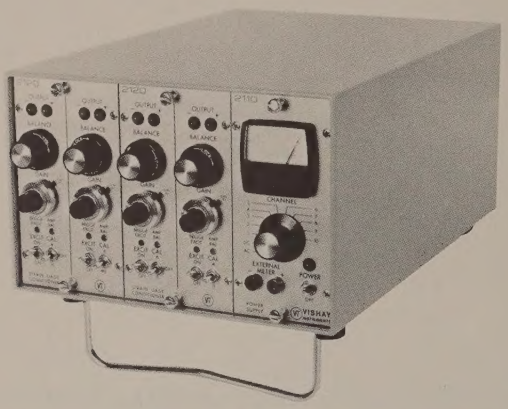
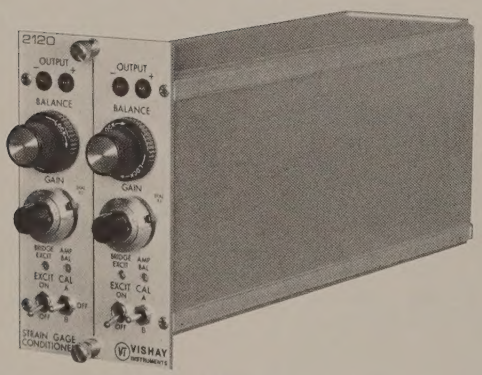


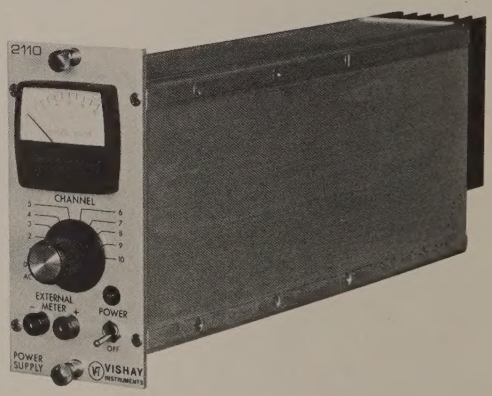
COMPLETE 10-CHANNEL 2100 SYSTEM



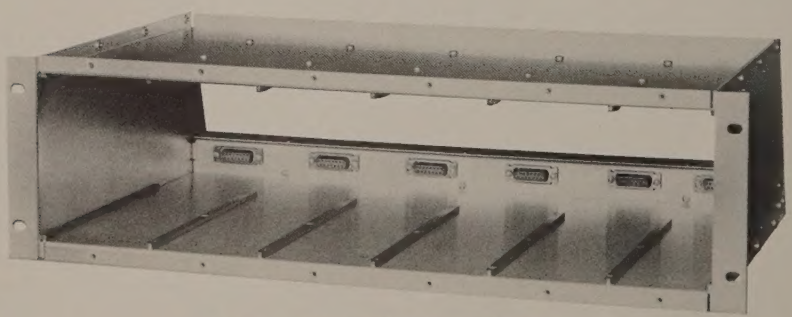
4-CHANNEL SYSTEM IN 2160 PORTABLE ENCLOSURE



2120 CONDITIONER MODULE



2110 POWER SUPPLY MODULE



2150 10-CHANNEL RACK ADAPTER

SECTION 1
DESCRIPTION

GENERAL

1.1 The Series 2100 modules comprise a multichannel system for generating conditioned high-level signals from strain gage inputs for display or recording on external equipment. A system would be comprised of:

a) One or more 2-channel 2120 Strain Gage Conditioners;

b) One or more 2110 Power Supplies (each Power Supply will handle up to 10 channels; i.e., five 2120 Conditioner/Amplifiers); and,

c) One or more rack adapters or cabinets, complete with wiring, to accept the above modules.

1.2 The principal features of the system include:

... Independently variable and regulated excitation for each channel (1 to 12 Vdc).

... Independently continuously variable gain (100 to 2100) for each channel.

... Bridge-completion components to accept quarter- (120Ω and 350Ω), half- and full-bridge inputs to each channel.

... LED null indicators on each channel – always active.

... 100 mA output.

... All supplies and outputs short-circuit proof with current limiting.

... Compact packaging – 10 channels in 5-¼ x 19 in (133 x 483 mm) rack space.

SPECIFICATIONS

All specifications nominal or typical at +23°C unless noted.

1.3 2120 STRAIN GAGE CONDITIONER

Note: These specifications apply for each of two independent channels per module.

INPUTS	Quarter (120Ω and 350Ω), half and full bridge (50-1000Ω). Quarter-bridge dummy resistors provided.
BRIDGE EXCITATION	1 to 12 Vdc (adjustable for each channel) with 120Ω full bridge load. Short-circuit current: less than 40 mA. Ripple, noise, and 10% line change: 2 mV max. Load regulation: ±0.2% no-load to 120Ω load.
BRIDGE BALANCE	±2000 με (quarter, half, or 350Ω full bridge); range can be changed by internal resistance change.
CALIBRATION	Two-position (center off) toggle switch. Standard factory-installed resistors (±0.1%) simulate ±1000με at GF=2.
AMP GAIN	100 to 2100 continuously adjustable. Gain equal to twice dial reading (±2%).
BANDPASS	dc to 5 kHz (min): ±0.5 dB (±5%) dc to 15 kHz: ±3 dB
AMP INPUT	Temperature coefficient: ±2 μV RTI/°C (max) [Referred to Input]. Warm-up: 25 μV RTI over 30 minutes. Noise and drift (pk-pk): dc – 10 μV RTI/day; 0.01 to 100 Hz – 3 μV RTI (max); 1 Hz up – 10 μV RTI (max). Input impedance: >25 MΩ differential or common mode (balance limit resistor removed). CMR: dc – 120 dB (min); 0 to 500 Hz – 100 dB Input bias: +0.1 μA each input.
OUTPUT	±10 V (min) at 30 mA; ±50 mA (min) into 150Ω load; ±100mA (min) into 15Ω load. Current limit: 120 mA. Linearity: ±0.05% at dc.
SIZE & WEIGHT	5.25 in H x 2.94 in W x 10.97 in D (133 mm x 75 mm x 279 mm) 2.2 lb (1.0 kg)

1.4 2110 POWER SUPPLY

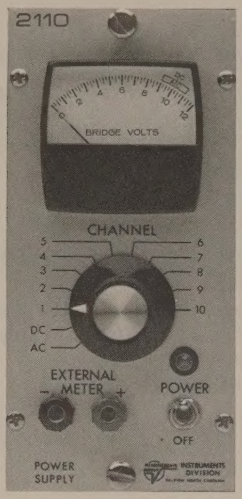
OUTPUTS	±15 V at 1.2 A and +17.5 V at 1.1 A; all regulators current-limited against overload.
INPUT	107, 115, 214, 230 Vac ±10% (selected internally); 50-60 Hz. Power: 40 W typical, 100 W max.
METER	0 to 12 Vdc (with switch) to read bridge excitation. Also ac input and dc output go/no-go monitor.
SIZE & WEIGHT	5.25 in H x 2.44 in W x 12.34 in D (133 mm x 62 mm x 313 mm) 6.7 lb (3.1 kg)

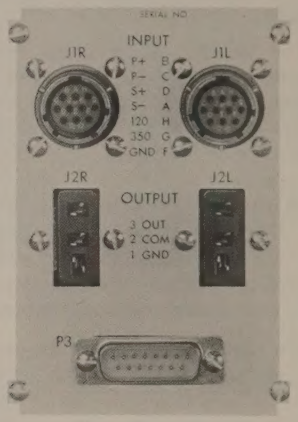
1.5 2150 RACK ADAPTER

APPLICATION	Fits standard 19-in (483-mm) electronic equipment rack. Accepts one 2110 Power Supply and one to five 2120 Strain Gage Conditioners. Completely wired.
POWER	2-ft (0.6-m) 3-wire line cord; 10-ft (3-m) extension available. Fuse: 1 A size 3 AG (32 mm x 6.4 mm dia.). Receptacle to accept line cord from adjacent 2150 Rack Adapter.
SIZE & WEIGHT	5.25 in H x 19 in W x 12.82 in D overall (133 mm x 483 mm x 325 mm) 6.6 lb (3.0 kg)

1.6 2160 PORTABLE ENCLOSURE

DESCRIPTION	Completely self-contained adapter and cabinet with all wiring for two or four channels. Accepts one 2110 Power Supply and one or two 2120 Strain Gage Conditioners.
POWER	8-ft (2.4-m) detachable 3-wire cord. Fuse: 1 A size 3 AG (32 mm x 6.4 mm dia.).
SIZE & WEIGHT	5.50 in H x 8.75 in W x 13.13 in D (140 mm x 222 mm x 333 mm) 5.2 lb (2.4 kg).





Rear View

CONTROLS

1.7 2110 POWER SUPPLY

BRIDGE VOLTS Meter — Displays the voltage on each input bridge (as selected by CHANNEL selector). Also used to monitor ac line and dc outputs of Power Supply (see below).

CHANNEL Selector — Positions 1 to 10 select channel to display bridge excitation on Meter ("1" is channel farthest to left in cabinet, etc).

The DC position monitors a mixed output from the +15, −15, and +17.5 V power supplies and should always read on the "DC" line at "10" on the Meter.

The AC position monitors the peak-to-peak ac line input (at a fixed transformer tap). A reading anywhere in the band from 9 to 11 on the Meter indicates that the input voltage is proper for the selected transformer tap (see paragraph 2.5). No reading indicates the equipment is ungrounded; noticeable needle vibration indicates reversal of the ac input line.

EXTERNAL METER Jacks — Supplies Meter voltage to an external meter if desired for precise adjustment of bridge supply voltages.

POWER Switch — The main power switch for this supply and all Conditioners connected to it. (The pilot lamp may take several seconds to extinguish when the power is turned off.)

1.8 2120 STRAIN GAGE CONDITIONER (one channel described; both identical and independent).

OUTPUT Lamps — LED indicators always monitoring amplifier output. Primarily used to adjust AMP BAL and Bridge BALANCE. (Fully lit with 0.07 V output.)

BALANCE Control — A 10-turn potentiometer to adjust bridge balance. Normal range ±2000 $\mu\varepsilon$. (See paragraph 2.26 to extend range.) EXCIT must be ON to set bridge balance.

GAIN Control — A 10-turn potentiometer to adjust amplifier gain. The nominal gain equals twice the dial reading (e.g., with the dial set at 500 the gain is approximately 1000). Gain is adjustable from 100 to 2100 (050 to 1050 on GAIN dial).

GAGE EXCIT — A 22-turn trimmer to adjust bridge excitation from 1 to 12 Vdc. The actual setting is monitored on the Meter and the EXTERNAL METER jacks on the 2110 Power Supply (the proper channel must be selected).

AMP BAL — A 22-turn trimmer to adjust the amplifier balance. (EXCIT should be OFF when this is done.) Thermal EMF's in the bridge may also affect this balance.

EXCIT switch — A toggle switch controlling the excitation to the input bridge. (Any amplifier output with EXCIT at OFF is dc amplifier offset, thermal EMF from the bridge or ac pickup in the wiring.)

CAL Switch — A 2-position (with center off) toggle switch to shunt-calibrate the input bridge. As delivered, "A" simulates +1000 $\mu\varepsilon$, and "B" simulates −1000 $\mu\varepsilon$ by shunting the internal 350Ω half bridge. Many other arrangements possible by internal-resistor and jumper changes (see Section 3).

INPUT receptacle (rear panel) — A 10-pin quarter-turn connector to connect input gage(s). (Quarter, half and full bridges can be accepted simply by using the appropriate pins. See paragraph 2.11 for details.) Mating connector supplied.

OUTPUT receptacle (rear panel) — A 3-pin connector delivers the amplifier output (±10 V or ±100 mA). Mating connector supplied.

SECTION 2

OPERATING PROCEDURES

SETUP AND AC POWER

2.1 The individual Conditioner and Power Supply modules are not stand-alone instruments. They are designed to plug into a prewired cabinet or rack adapter which (1) supplies ac line power (fused) to the Power Supply, (2) distributes dc regulated voltages to all Conditioners and (3) connects the bridge voltage monitoring meter in the Power Supply to the various channels.

If one or more 2150 10-channel Rack Adapters are used, these should be mounted in a standard 19-in (483-mm) equipment rack; 5¼ inches (159-mm) vertical height is required for each 10 channels.

2.2 Before installing a 2110 Power Supply module in each cabinet or rack adapter, check that each 2110 module is set for the proper ac line voltage:

Slide the right-hand side cover almost all the way back to expose the two toggle switches on the printed-circuit board. One switch, as marked, sets for nominal 115 or 230 V; the other sets for NORM line (115/230 V ±10%) or LOW line (107/214 V ±10%). Replace side cover.

Install the Power Supply in the right-hand position of the cabinet; push in to engage the input/output plug and secure the thumb screws. The POWER switch on the front panel should be at OFF.

2.3 Install 2120 Conditioners in the remaining positions in the cabinet. Push in the modules to engage the power-input plugs and secure the thumb screws. (If there is less than a full complement, it makes little difference which positions are used. Blank covers are available for unused positions.)

2.4 Plug the line cord into an ac receptacle, making certain that the third pin goes to a good ground. The equipment *must* be grounded for good performance.

NOTE: If the line plug must be replaced with a different type, observe this color code when wiring the new plug.

Black: High line voltage
White: Low line voltage (i.e., "neutral" or common)
Green: Ground

If one 2150 Rack Adapter is used, a 3-wire extension cord may be required.

If more than one 2150 Rack Adapter is used, one should be plugged into a powered ac receptacle, while the other Rack Adapters are plugged into each other (using the utility receptacles at the rear) in any sequence.

NOTE: The fuse at the rear of each Rack Adapter only fuses the input to the Power Supply in that Rack Adapter. The utility receptacle is *not fused.*

2.5 Check ac power. On each Power Supply, turn the CHANNEL selector to "AC". Turn the POWER switch on (up). The red pilot lamp should light and the meter should read between 9 and 11 on the scale. If not, observe meter reading:

Pegs at full scale. Turn power off immediately. This indicates that the input voltage is much too high for the internal switch settings (probably a 230 V input with switches set for 115 V; see paragraph 2.2).

Reads low (between 8 and 9¼). The ac line voltage is significantly below 115 V (or 230 V). Remove Power Supply and reset internal switch for LOW line.

Reads around 5. This probably indicates that the internal switches are set for 230 V input, whereas the voltage is actually 115 V. Turn POWER OFF, remove module, and reset switches (see paragraph 2.2).

Reads 0 (no reading).
Red pilot lamp not lit: The ac receptacle has no power or the fuse (at the rear of the instrument) is open. Pilot lamp lit: Equipment is not properly grounded. Either the third pin was not used, or the receptacle used is not properly grounded.

If the meter reads properly but the pointer vibrates noticeably (at 50 or 60 Hz), the "phasing" of the input is improper. Reverse the line wiring.

2.6 Check dc power. On each Power Supply, turn the CHANNEL selector to "DC". The meter should read very near the line at 10 on the scale. If not, this indicates that either (l) there is an internal short in one of the Conditioner modules (remove them one at a time), or (2) one or more of the regulated power supply circuits is defective (see paragraph 4.4).

2.7 Check bridge excitation regulators. Scan the CHANNEL switch through positions 1 to 10; all positions should read some voltage between 1 and 12 volts. (However, switch positions corresponding to channels not installed will, of course, read zero.)

2.8 The system is now ready for use. If it is planned to use the system immediately, it is suggested that the POWER be left on (for warm-up); otherwise turn all POWER switches to OFF.

INPUT CONNECTIONS

2.9 It is suggested that the system be turned on and allowed to stabilize while preparing the input connectors; power consumption is negligible. To prevent powering any input circuits at this time, turn the EXCIT toggle switches OFF on all channels.

2.10 Each channel uses a separate (and interchangeable) input plug. Two loose plugs are supplied with each 2120 Conditioner (one per channel). If additional plugs are desired they are available from Measurements Group (see paragraph 4.3) or from the manufacturer or his distributors. Suggested types:

ITT/Cannon KPT06B12-10P
Bendix PT06A-12-10P(SR)

These connectors are designed to MIL-C-26482 and may be available from additional sources.

2.11 Connect the input to each channel, using the connectors supplied, in accordance with Fig. 1.

Note: Except when using an external full bridge, *there must be a jumper in the plug connecting pins D and E;* this connects the midpoint of the internal 350Ω half bridge to the S+ amplifier input, thus completing the necessary full bridge for proper amplifier operation.

No modifications or jumpers are required inside of the 2120 Conditioner regardless of the external bridge configuration used. (However, there are provisions for changing the shunt calibration circuit – see Section 3.)

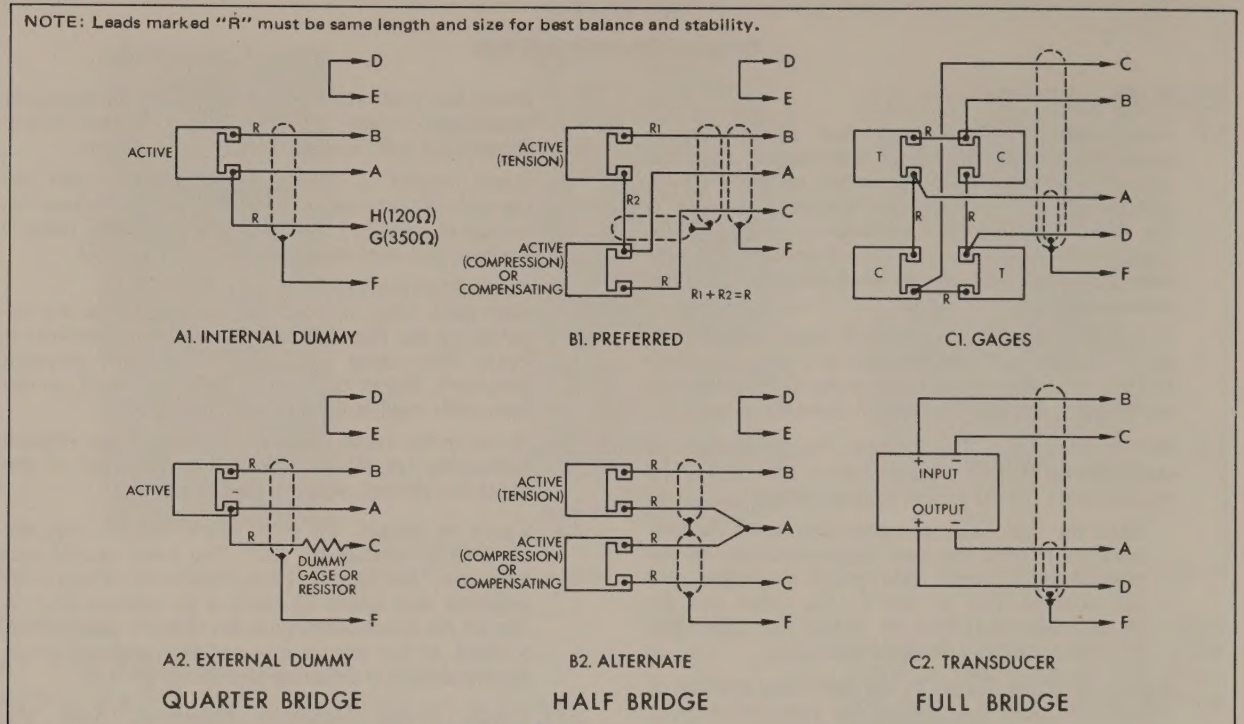


Fig. 1: Input Circuits

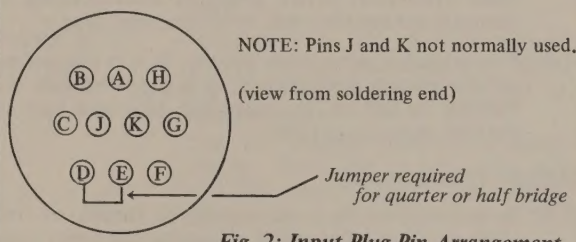


Fig. 2: Input Plug Pin Arrangement

WIRING CONSIDERATIONS

2.12 Certain important considerations affect wiring technique, depending on whether the purpose of the test is to measure static or dynamic data; if both may be required, observe both sets of precautions.

Dynamic Data: It is extremely important to minimize the extent to which the gages and leadwires pick up electrical noise from the test environment; this noise is usually related to the 50 or 60 Hz line power in the area:

a) *Always* use twisted multiconductor wire (*never* parallel conductor wire); shielded wire is greatly preferred, although it may prove unnecessary in some cases using short leads.

b) Shields should be grounded at one (and only one) end; normally the shield is grounded at the INPUT connector and left *disconnected* (and insulated against accidental grounding) at the gage end. Do not use the shield as a conductor (that is, do not use coaxial cable as a 2-conductor wire).

c) The specimen or test structure (if metal) should be electrically connected to a good ground.

d) Keep all wiring well clear of magnetic fields (shields do not protect against them) such as transformers, motors, relays and heavy power wiring.

e) With long leadwires, a completely symmetrical circuit will yield less noise (e.g., a half bridge on or near the specimen will usually show less noise than a true quarter-bridge connection).

Static Data: Precise symmetry in leadwire resistance is highly desirable to minimize the effects of changes in ambient temperature on these wires.

a) In the quarter-bridge circuit, *always* use the 3-leadwire circuit shown in Fig. 1, rather than the more obvious 2-wire circuit.

b) Insofar as possible, group all leadwires to the same channel in a bundle to minimize temperature differentials between leads.

c) If long leads are involved, calculate the leadwire desensitization caused by the lead resistance. If excessive in view of data accuracy required, adjust effective gage factor, increase wire size, or increase gage resistance — or all three, as best suits the situation.

MILLIVOLT INPUTS

2.13 The 2120 Conditioner can accept low-level dc inputs, such as thermocouples (using pins A and D), provided two requirements are observed:

a) The common-mode voltage should not exceed ±6 V in normal operation, and must *never* exceed a peak voltage of ±15 V.

b) The input cannot be completely floating; there must be a ground return, either external or within the 2120. In the case of thermocouples welded to a nominally grounded structure, this return is adequate. A 75-kΩ ground return exists within the standard 2120 due to the presence of the bridge-balance circuit. However, if the external signal is adequately grounded, this resistance can be removed (remove R7 — see paragraph 2.26).

The user is also cautioned regarding two sources of possibly significant error:

a) Bias current: Each input (pins A and D) requires an input current of approximately +100 nA; this current will flow through the input wiring to the ground return, which must exist. With a floating input (in which case R7 must remain installed), the bias required at pin D will flow directly from R7, but the bias for pin A will flow through the entire input circuit; with low source impedances this is insignificant and can be offset with the AMP BAL control. High source impedances can result in measurable offsets (with a 5000Ω source impedance the offset may approach 1 mV, which considerably exceeds the range of the AMP BAL control).

b) Any nonsymmetry in the ground returns of the inputs will reduce the CMR of the amplifier to some degree.

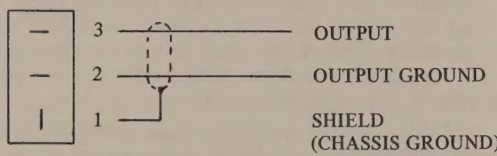
OUTPUT CONNECTIONS

CAUTION: If it is possible in any way to damage the indicator or recorder connected to the OUTPUT with inputs of 15 V or 120 mA, the OUTPUT should not be connected until the channels have been balanced (paragraphs 2.25 and 2.26).

2.14 Each channel uses a separate output plug. Two loose plugs are supplied with each 2120 Conditioner (one per channel). If additional plugs are desired they are readily available from Measurements Group, Inc. or through electronic parts distributors:

Cinch-Jones P-303-CCT-L

2.15 Three pins are provided for each channel:



It is probably not essential that the output leads be shielded, but in critical low-level situations it may be advisable.

Pin 2 is circuit ground, which is connected at one point to chassis-ground (in the cabinet or rack adapter harness). If the OUTPUT is connected to a low impedance device (such as a galvanometer), it is essential that this device be connected between pins 3 and 2; any other connection may cause crosstalk between channels. However, if the output is to be fed into a high impedance device (such as an oscilloscope) which has only a single input pin (plus ground), this input can be connected to pin 3 of the OUTPUT plug with little error (typically 1 mV referred to the output) due to crosstalk between channels; of course a differential input (using pins 3 and 2) is preferred.

2.16 It should be noted that the OUTPUT indicator lamps on the front of the 2120 at all times monitor the voltage between pins 3 and 2 of the OUTPUT receptacle. If both lamps are extinguished, the output voltage is zero (within 7 mV maximum circuit offset). Full brilliance of either lamp indicates a voltage in excess of 70 mV (possibly as high as 14 V).

OUTPUT LIMITS

2.17 The output is capable of ±10 V into a load of 300Ω or higher. With a load of 15Ω or lower, the output will deliver up to ±100 mA, but in no case greater than 120 mA. The characteristics of the current limit are as follows:

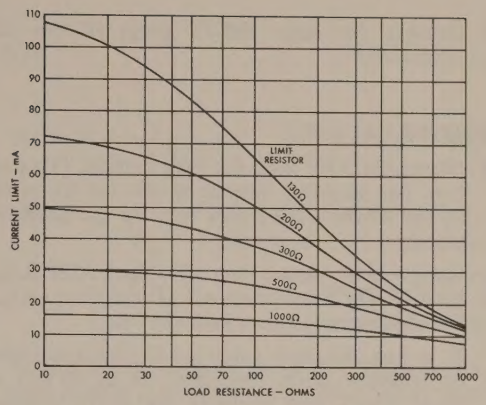


Fig. 3: Output Limit Characteristics

The max. output can readily be limited to less than 120 mA by increasing the value of two resistors per channel (R29 and R30, normally 130Ω ±2%), as shown in Fig. 3. It is suggested that below 500Ω 1-W resistors be used; between 500Ω and 1000Ω use at least ½-W resistors.

An alternate procedure to reduce the max. current in the load is to add a resistor *across* that load; e.g., a 175Ω resistor across a 100Ω load will reduce its max. current from 66 mA to 50 mA; the actual value of the resistor should be determined by test.

OPERATION

2.18 On each channel make certain that the EXCIT switches are OFF (thus removing excitation to all gage circuits) and the CAL switches are in the center (OFF) position.

2.19 If it is possible to damage or overload the indicators or recorders connected to the OUTPUTS with 15 Vdc (or 120 mA for low-resistance devices), the OUTPUT plugs should *not* be plugged in at this time.

2.20 On the Power Supply module, turn the POWER switch on. The red pilot lamp should light.

2.21 On the Power Supply module, set the CHANNEL selector at AC; the meter should read within the AC band on the Meter.

2.22 Turn the CHANNEL selector to DC; the meter should read on the DC check line.

EXCITATION

2.23 Set desired excitation on each channel: turn the CHANNEL selector to channel 1; on the leftmost channel, adjust BRIDGE EXCIT (using a small screwdriver) to read the desired BRIDGE VOLTS on the Power Supply Meter.

If greater accuracy is desired than can be achieved with the small meter, connect an external meter to the EXTERNAL METER banana jacks on the Power Supply (the minus jack is nominally chassis-ground).

Turn CHANNEL selector to channel 2 and repeat this procedure adjusting BRIDGE EXCIT on the next channel; continue until all installed channels are satisfactorily adjusted.

NOTE: To achieve best stability and lowest noise at the output, it is desirable to use the maximum excitation that the input to each channel can accept. Small or low-resistance gages or gages bonded to a poor thermal conductor (such as most plastics or composites) must necessarily use low excitation.

2.24 Connect the gage INPUT plugs (if not already connected).

AMPLIFIER BALANCE

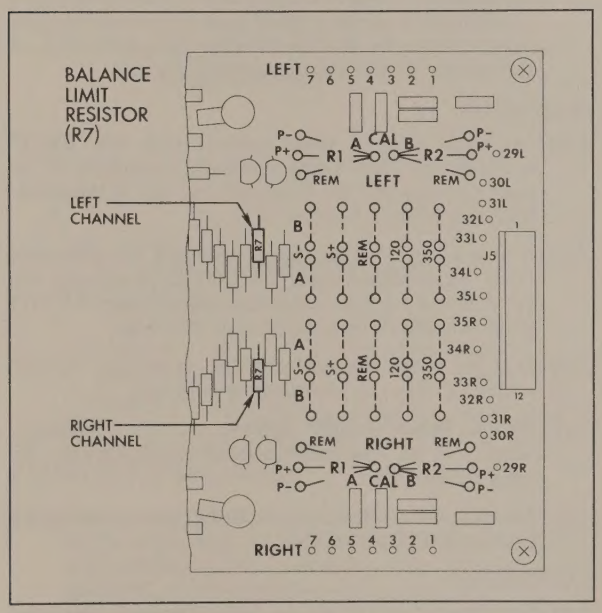
2.25 Adjust the AMP BAL for each channel. (To some extent the amplifier balance is affected by symmetry of the source impedances seen by the amplifier inputs.)

Using a small screwdriver, adjust each AMP BAL until both OUTPUT lamps are off. (If the +lamp is lit, turn the adjustment counterclockwise, etc.)

If, at best null, both lamps are lit, this is an indication of excessive noise (probably 50 or 60 Hz) at the input. Check wire shielding, etc. Refer to paragraph 2.12 for further discussion.

BRIDGE BALANCE

2.26 Adjust balance on each channel. On each channel, turn the EXCIT switch to ON; then turn the BALANCE control to extinguish OUTPUT lamps, as above.



NOTE: As delivered, the BALANCE controls can correct for approximately ±2000$\mu\varepsilon$ unbalance in quarter, half or 350Ω full bridge. With full bridge inputs other than 350Ω, the balance range will be reduced for lower bridge resistance and increased for higher ones. For example, with a 120Ω full bridge, the balance range is reduced to under ±700$\mu\varepsilon$. If the balance range proves inadequate for the gages or transducers in use, the "balance limit resistor" (R7, normally 75kΩ) should be replaced with a lower value (or shunted with an additional resistor).

2.27 Connect OUTPUT plugs for each channel (unless already connected).

GAIN

2.28 Adjust GAIN for each channel. There are two general methods of setting the GAIN control:

a) Mathematical: In many cases it is possible to predict the amplifier gain required; then this can be preset. For example, assume the input is one active gage with GF = 2 and bridge excitation has been set at 5 Vdc. Further assume that the desired output is 2 Vdc for 500$\mu\varepsilon$. At 500$\mu\varepsilon$ the bridge will deliver 500 x 2.5 μV = 1.25 mV; to achieve 2 V output from the amplifier will require a gain of 1600. Set the GAIN control at 800, since the nominal amplifier gain equals twice the dial reading.

b) Empirical: Without regard to bridge excitation or amplifier output voltage, assume that the desired output is 25 mm deflection on a recorder for a 500$\mu\varepsilon$ input. Using shunt calibration (such as the 1000$\mu\varepsilon$ built into the 2310 Conditioner), adjust the GAIN as required to achieve the desired deflection – for example, the 1000$\mu\varepsilon$ cal in the 2120 should give 50 mm deflection (assuming GF = 2, for which the calibration resistors are calculated).

In practice, even though the mathematical approach is possible in many situations, the shunt-calibration method should also be used as the final exact adjustment.

The user is cautioned to consider the effects of leadwire resistance and the calibration circuit actually in use when calculating the strain simulated by shunt calibration. See Section 3.

2.29 All controls are now set. However, just before taking data, it is advisable to check balances on each channel:

a) Briefly turn EXCIT to OFF; if the OUTPUT lamps are not at null (both extinguished) trim AMP BAL as necessary. This can be done at any time during a test – and should be done occasionally on an extended test.

b) Under no-load conditions (and with CAL at OFF) the OUTPUT lamps should indicate null; if not, trim the BALANCE control.

NOTE: In both steps above it may be desirable to observe the output recorder rather than the OUTPUT lamps. First, there may be a very small offset (5-10 mV) between true zero output and the zero indicated by the lamps and, second, it may be necessary to compensate for a small mechanical or electrical zero offset in the recording device.

NOISE

2.30 Before taking dynamic data, it is highly desirable to document the output noise attributable to wiring and other sources vs. the total dynamic output which includes this noise plus the dynamic strain signals:

Momentarily turn EXCIT to OFF and observe the output. Any signal observed now is NOT caused by strain (whether a dynamic strain is being generated or not). "White" noise (full spectrum) is due to the amplifier and cannot be reduced except by reducing GAIN – it should not exceed several microvolts RMS referred to the input (that is, the observed signal divided by amplifier gain). A recurrent waveform (usually 50 or 60 Hz or multiples of this frequency) indicates electrical pickup at the gages or in the wiring to the gages; if excessive, the source should be located and corrective measures taken.

NOTE: It should be emphasized that the purpose of shunt calibration is to determine the performance of the *circuit* into which the gage(s) is wired, and in no way does it verify the ability of the *gage* itself to measure strain nor the characteristics of its performance.

EQUATIONS

3.1 Shunt calibration can be achieved by shunting any one of the four arms of the input bridge (which includes an active gage(s) and the bridge completion resistors within the 2120 Conditioner). The 2120 provides for shunting any of these arms. No matter which arm is shunted, the same equation applies:

$$\mu\varepsilon_{CAL} = \frac{R'_a}{K'(R_{CAL} + R'_a)} \times 10^6 \qquad \text{(Eq. 3-1)}$$

where: $\mu\varepsilon_{CAL}$ = strain simulated (microstrain)

R'_a = precise effective resistance of arm shunted (ohms)

K' = effective gage factor of strain gage

R_{CAL} = resistance of calibration resistor (ohms)

K′ may be the actual package gage factor of the strain gage in use, or it may be adjusted for leadwire desensitization:

$$K' = K \frac{R_g}{R_g + R_\ell} \qquad \text{(Eq. 3-2)}$$

where: K = package gage factor of active gage

R_g = resistance of strain gage (ohms)

R_ℓ = resistance of leadwire(s) in series with the active gage (usually the resistance of *one* leadwire—ohms)

When shunting either bridge arm to which the balance limit resistor is connected, it is theoretically necessary to correct for this shunting effect in determining R'_a. While the exact value depends on the position of the balance potentiometer, a good approximation (which assumes the pot is at mid position) is:

$$R'_a = \frac{R_a (R_p + 4R_{BL})}{2R_a + R_p + 4R_{BL}} \qquad \text{(Eq. 3-3)}$$

where: R_a = resistance of resistor or gage in arm

R_p = resistance of balance potentiometer

R_{BL} = resistance of balance limit resistor

It should be noted that, for the 2120 Conditioner as shipped (where shunt calibration is across the 350Ω dummy half bridge), this correction is only 0.2%.

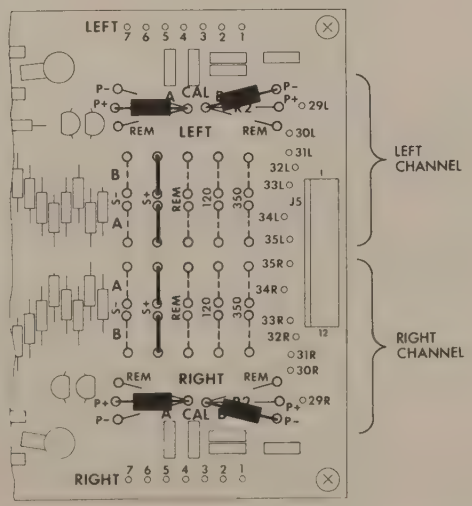
3.2 SHUNTING INTERNAL DUMMY HALF BRIDGE (350Ω):

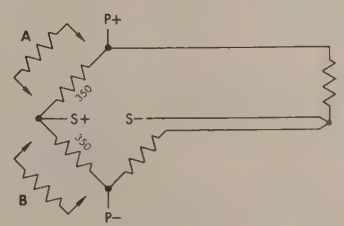
Use: Quarter and half bridge (full bridge with reduced accuracy).

Advantages: Same resistors regardless of active gage resistance. No special wiring required. Can simulate tension and/or compression.

Disadvantage: Leadwire desensitization may be significant (use equation 3-2 in equation 3-1).

Location of resistors and jumpers on the printed circuit board is shown in Figs. 4, 5, and 6. (Note that separate resistors are used for CAL A and CAL B, so that these may be different values; to calculate strain use R'_a = 349.3Ω).

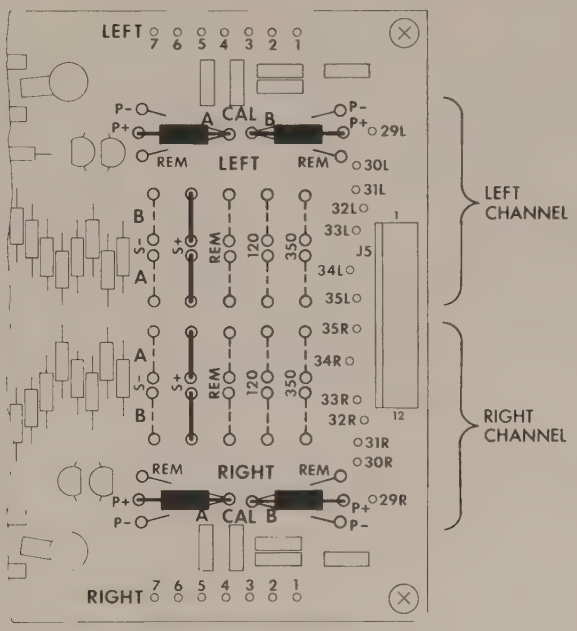


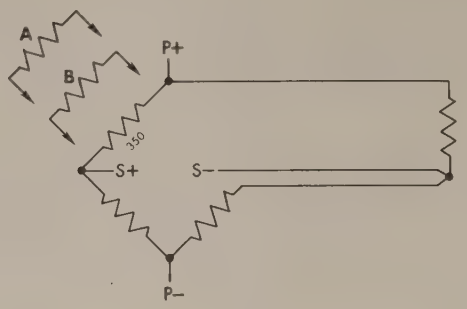


CAL A: Tension (+)
CAL B: Compression (−)

NOTE: This is standard configuration of the 2120 as shipped.

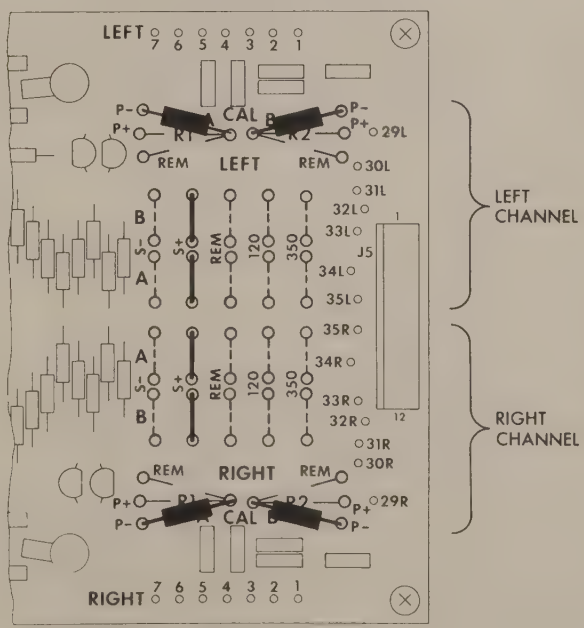
Fig. 4: Cal on Dummy Half Bridge (Tension and Compression)

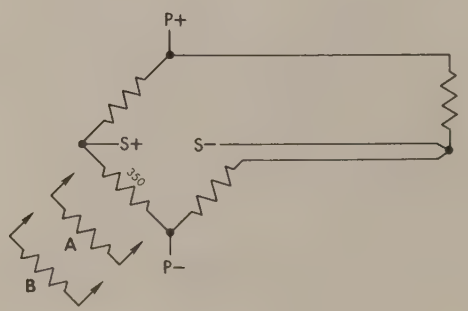




CAL A & B: Tension (+)

Fig. 5: Cal on Dummy Half Bridge (Tension)





CAL A & B: Compression (–)

Fig. 6: Cal on Dummy Half Bridge (Compression)

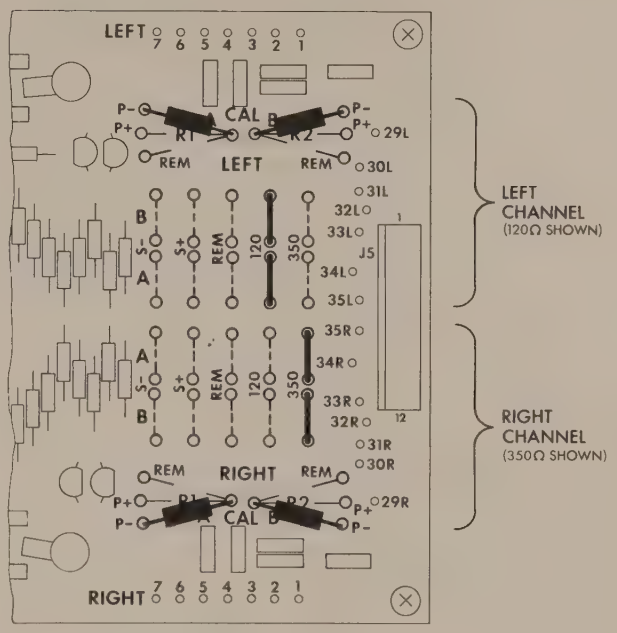
3.3 SHUNTING INTERNAL DUMMY RESISTOR (120Ω or 350Ω):

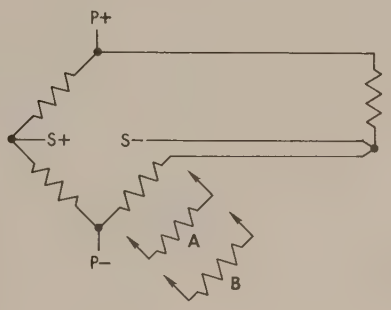
Use: Quarter bridge only

Advantage: Automatically corrects for leadwire desensitization (using 3-wire circuit). No special wiring. Accuracy independent of precise gage resistance.

Disadvantage: Only usable if internal dummy resistors are in use. Simulates tension only.

Location of resistors and jumpers on the printed circuit board is shown in Fig. 7. R'_a is resistance of dummy resistor. K′ = K.





CAL A and CAL B: Tension (+)

Fig. 7: Cal on Dummy Resistor

3.4 SHUNTING ACTIVE GAGES

While there is no electrical problem in shunting active gages *at the specimen* (they must be accessible and not completely coated), accomplishing this at the Conditioner with only the usual 3-lead connection will introduce serious errors if the leadwires have measurable resistance. The reason is that one *signal* lead which is supposed to be only a remote voltage-sensing lead, now carries current (to the calibration resistor); the error thus introduced is approximately *four times* that which would be expected by normal "leadwire desensitization" equations.

The above problem applies equally to active (or compensating) gages in stress analysis and to *all transducer* applications.

As a rough guide, 1% error will be introduced if the resistance of each lead is:

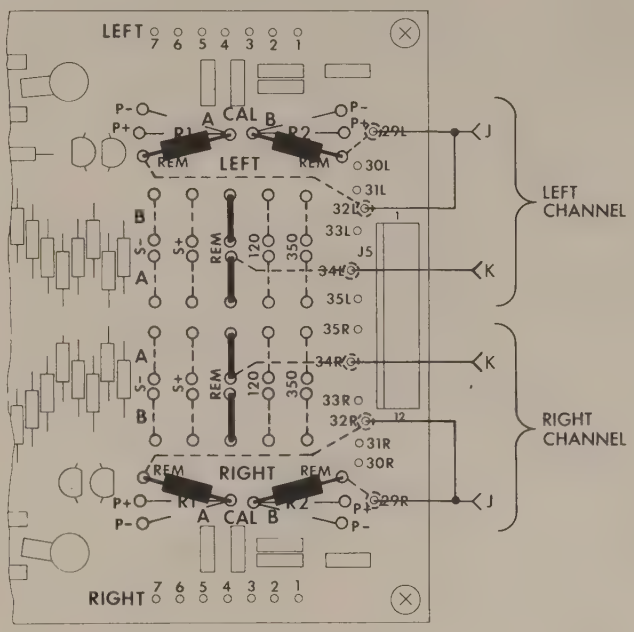
120Ω gages:
0.3Ω (7 ft AWG #26, 30 ft AWG #20)
(2.1 m, 0.4 mm dia; 9 m, 0.8 mm dia)

350Ω gages:
0.9Ω (20 ft AWG #26, 85 ft AWG #20)
(6 m, 0.4 mm dia; 25 m, 0.8 mm dia)

3.5 To properly shunt-calibrate active gages or transducers, the accepted technique is to provide two additional leads dedicated to the calibration circuit; for quarter-bridge operation this is customarily called the "five-leadwire circuit."

Positions are provided on the 2120 Conditioner circuit board for this application, but *wires must be added* between the circuit board and INPUT connector (using pins J and K, normally not used). Figs. 8 and 9 show a half bridge, but the calibration wiring also applies to full bridges and transducers; for true quarter bridges, Fig. 8, compression only, applies.

The added external leads should be connected directly to the strain gage terminals. R'_a = actual gage resistance. K′ = K. (In a transducer, the connection should be made at the connector on the transducer. R'_a would be the output impedance of the transducer.)



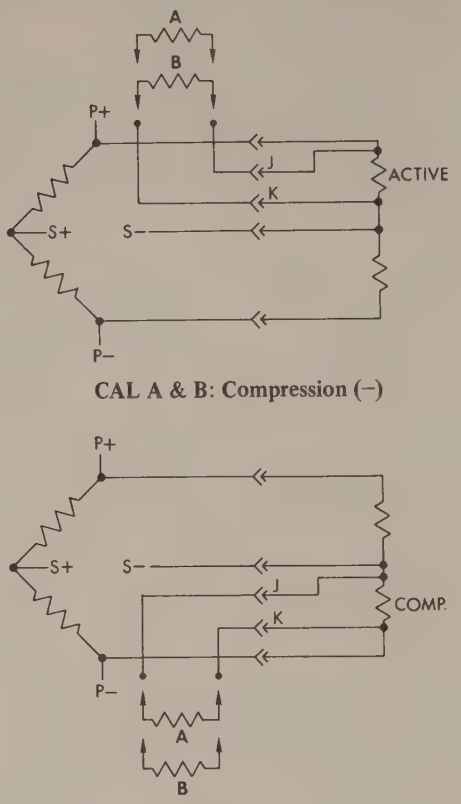
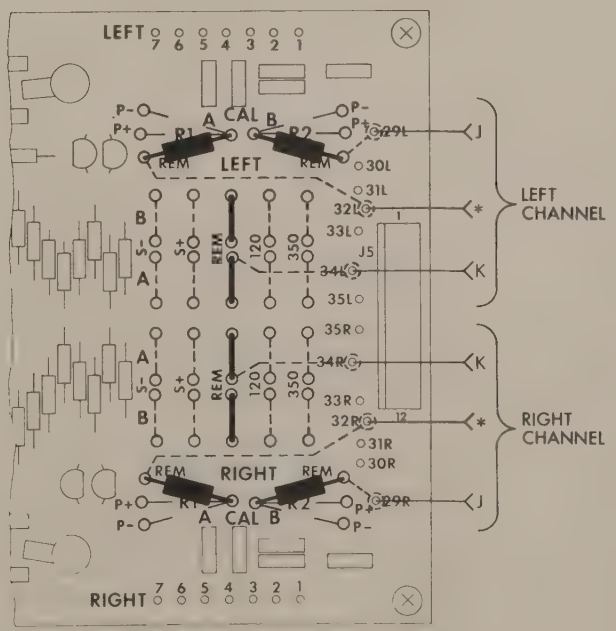
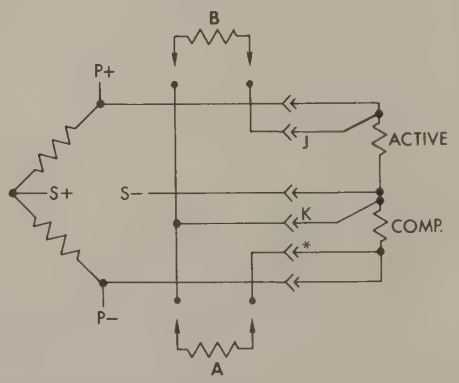


Fig. 8: Cal on Active Gage (Tension or Compression)





***No vacant pin available. Remove existing wire and use pin G, H, or F.**

CAL A: Tension (+)
CAL B: Compression (–)

Fig. 9: Cal on Active Gage (Tension and Compression)

SECTION 4

SERVICING DATA

CUSTOMER MODIFICATIONS

4.1 There are several simple modifications that can be made by the customer to suit specific measurement requirements. However, it should be noted that these modifications will, to some extent, affect overall performance:

a) Shunt-calibration circuit and magnitude: See Section 3.

b) Increase bridge BALANCE range: See paragraph 2.26.

c) Increase bandpass: The 2120 is limited to 5 kHz (0.5 dB down) at maximum gain (X2100) due to the gain-bandpass product of the circuit components. At lower gains the bandpass is intentionally limited to 5 kHz by C4 (.0027 μf). If C4 is removed (and C3 reduced to .003 μf) the bandpass will be increased to 25 kHz (0.5 dB down) at gains up to X500; but note that the 25 kHz output may be only 8 V pk-pk.

d) Reduced gain. The gain can be reduced below X100 by reducing R24. However, it should be noted that the preamplifier (Q1A/Q1B, IC1, IC2) has a fixed gain of X100 so that reducing R24 makes IC3 a fractional-gain stage. Below an overall gain of X100 it may not be possible to achieve ±10 V output.

The preamplifier gain can be reduced by decreasing R13 and R21; this technique will reduce overall gain and still maintain full ±10 V output. However, noise, drift, and input impedance will be adversely affected.

e) The sensitivity of the LED OUTPUT indicators can be changed by altering the value of R32; increasing R32 will increase sensitivity and vice versa.

f) Output current limit: The current level at which the output limits is controlled by R29 and R30. It may be desirable to reduce this limit by increasing the value of the resistors. See paragraph 2.17.

SERVICING

4.2 Individual schematics of the various modules are included at the back of this instructional manual. To facilitate service, 3-ft (0.9-m) extension cables are available to operate the modules outside the rack or enclosure:

15-pin (for 2120) P/N 200-130596
25-pin (for 2110) P/N 200-130597

COMPONENT REPLACEMENT

4.3 The majority of components used in the 2110 Power Supply and 2120 Conditioner are standard commercially available items. Any component can be purchased from Measurements Group (please provide us with component symbol, value, and module serial number). The following comments apply:

General: All 5% and 10% resistors are Allen-Bradly composition resistors, as marked (except Power Supply resistors R2, R7, R12 are TRW/IRC). All 1% resistors are 100 ppm/°C. All 0.02% resistors are Vishay (2 ppm/°C), and must be ordered from Measurements Group.

2110 Power Supply

	Part No.
Meter M1	200-130583
Switch S2	200-130584
Transformer T1	200-130663
Regulator, IC1-IC3 (LM723CN, Fairchild or National Semiconductor)	14X700040
Transistor, Q1-Q3 (2N5977, Motorola)	14X200167

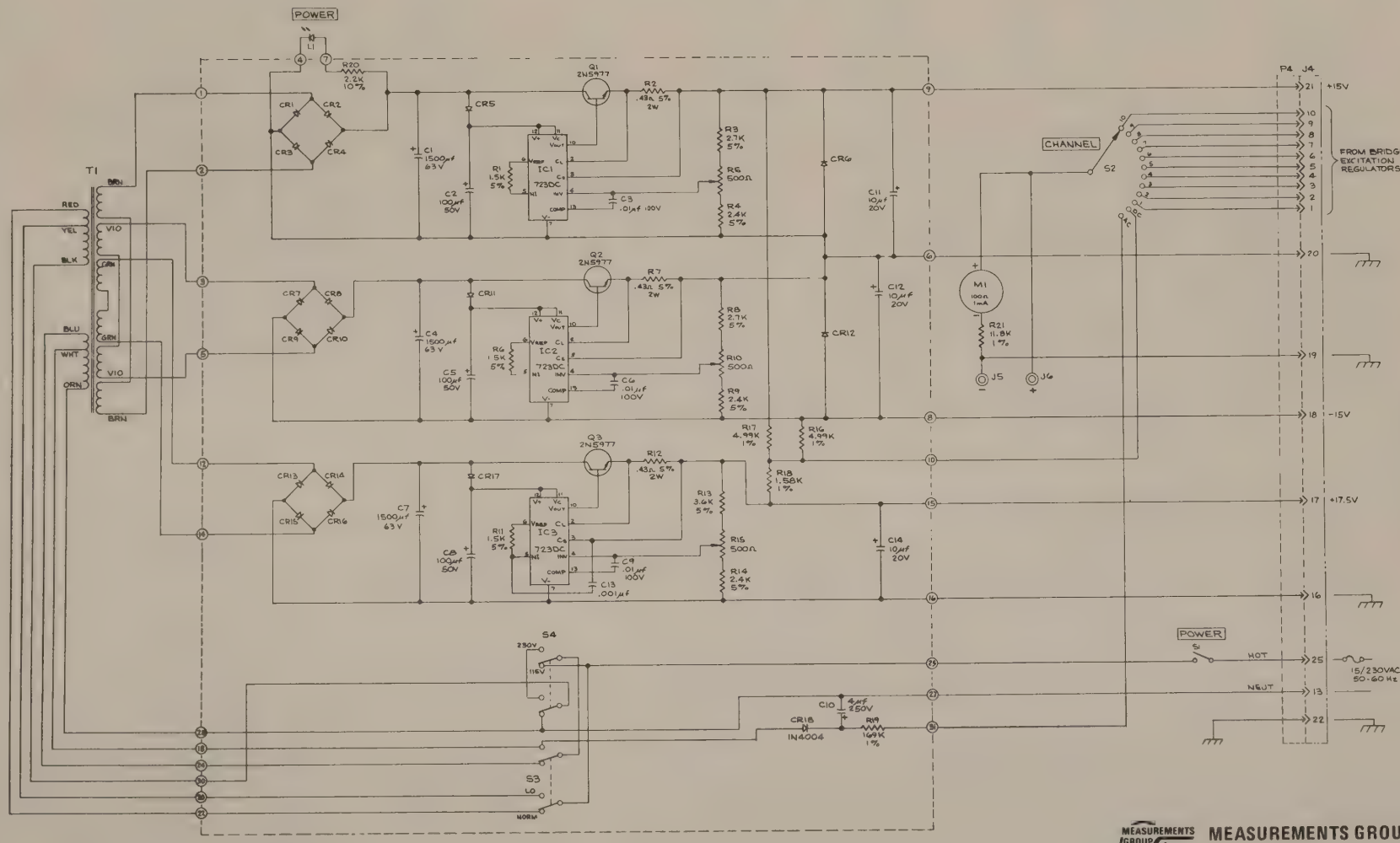
2120 Conditioner

Input plug, P1	12X300515
Output plug, P2	12X300556
Transistor, Input (Q1A, B)	14X200181
Transistor, Q3 or Q4 (graded)	140-000020
Amplifier, IC1 (OP-07DP)	14X700087
Amplifier, IC2 (AN201N, Analog Devices)	14X700041
Amplifier, IC3 (LM351N, National recommended)	14X700066
Amplifier, IC4 (LM307N, Fairchild recommended)	14X700042
Regulator, IC5 *(ceramic)* (723DC, Fairchild recommended)	14X700032

ADJUSTMENTS

4.4 The only adjustments in the 2110 Power Supply are to trim the exact output voltage. The adjustments (from the top) control +17.5 V, −15 V, +15 V; these should be set within 1% if possible, although they are not highly critical.

The only adjustments in the 2120 Conditioner are for common mode rejection. Short the two input pins of one channel (pins A and D) together and supply a low frequency (10 to 20 Hz) input, 2 to 5 V peak-to-peak, with respect to ground (pin C). Adjust the trimmer R14 to achieve minimum ac output. (If it is desired to check the CMR with an input resistance other than zero, it is necessary to temporarily remove R7 during these tests. To adjust high frequency CMR, raise the test frequency to 500 Hz and adjust the piston capacitor C10 to achieve minimum ac output.

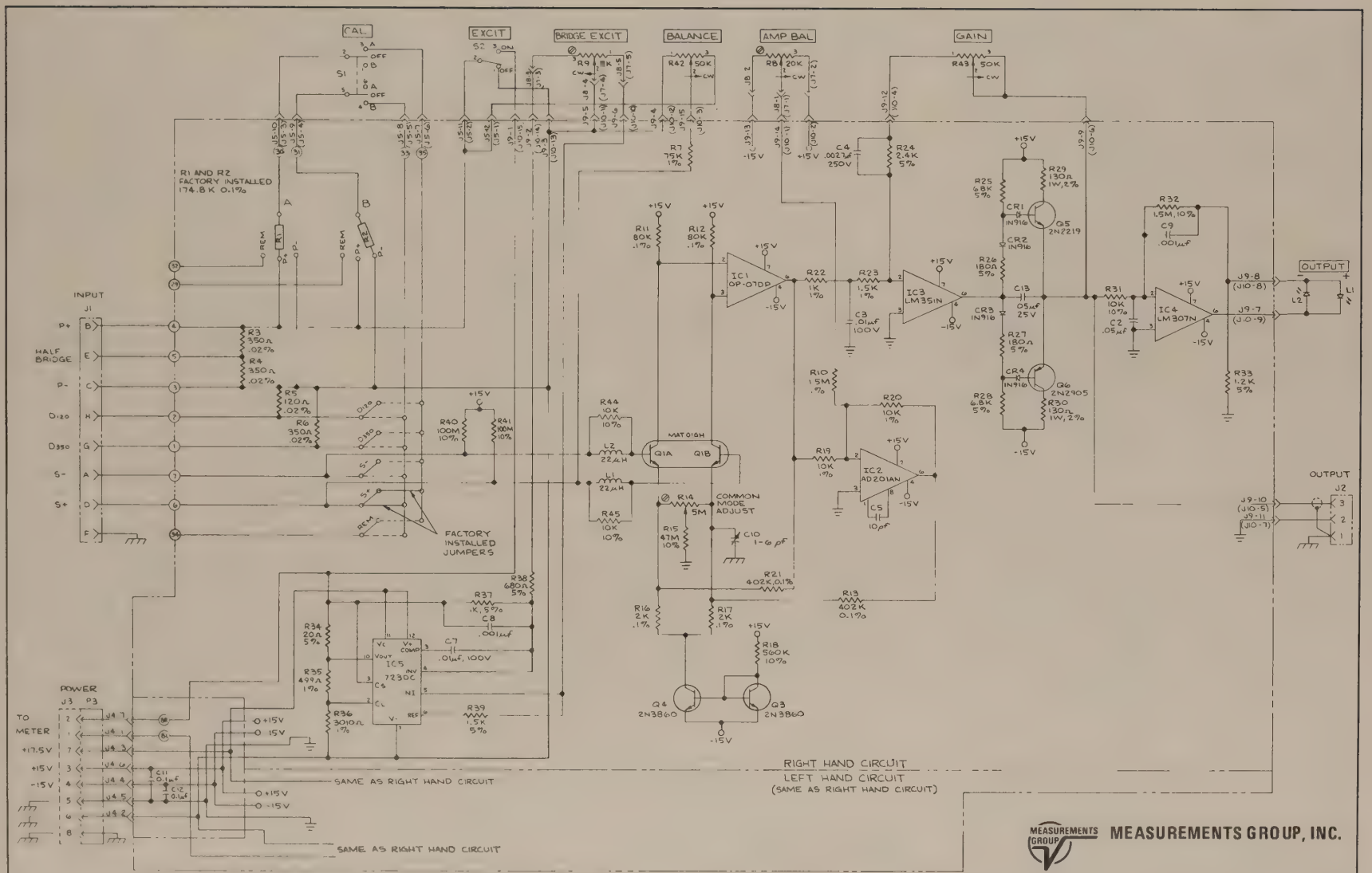


MEASUREMENTS GROUP, INC.

SCHEMATIC
POWER SUPPLY
2110

400-052630G

These drawings and specifications are intended to provide information for the proper utilization or maintenance or calibration or repair of the items represented. They are, and shall remain the property of Measurements Group, Inc., and shall not be reproduced or copied, in whole or in part, as the basis for manufacture or sale of such item



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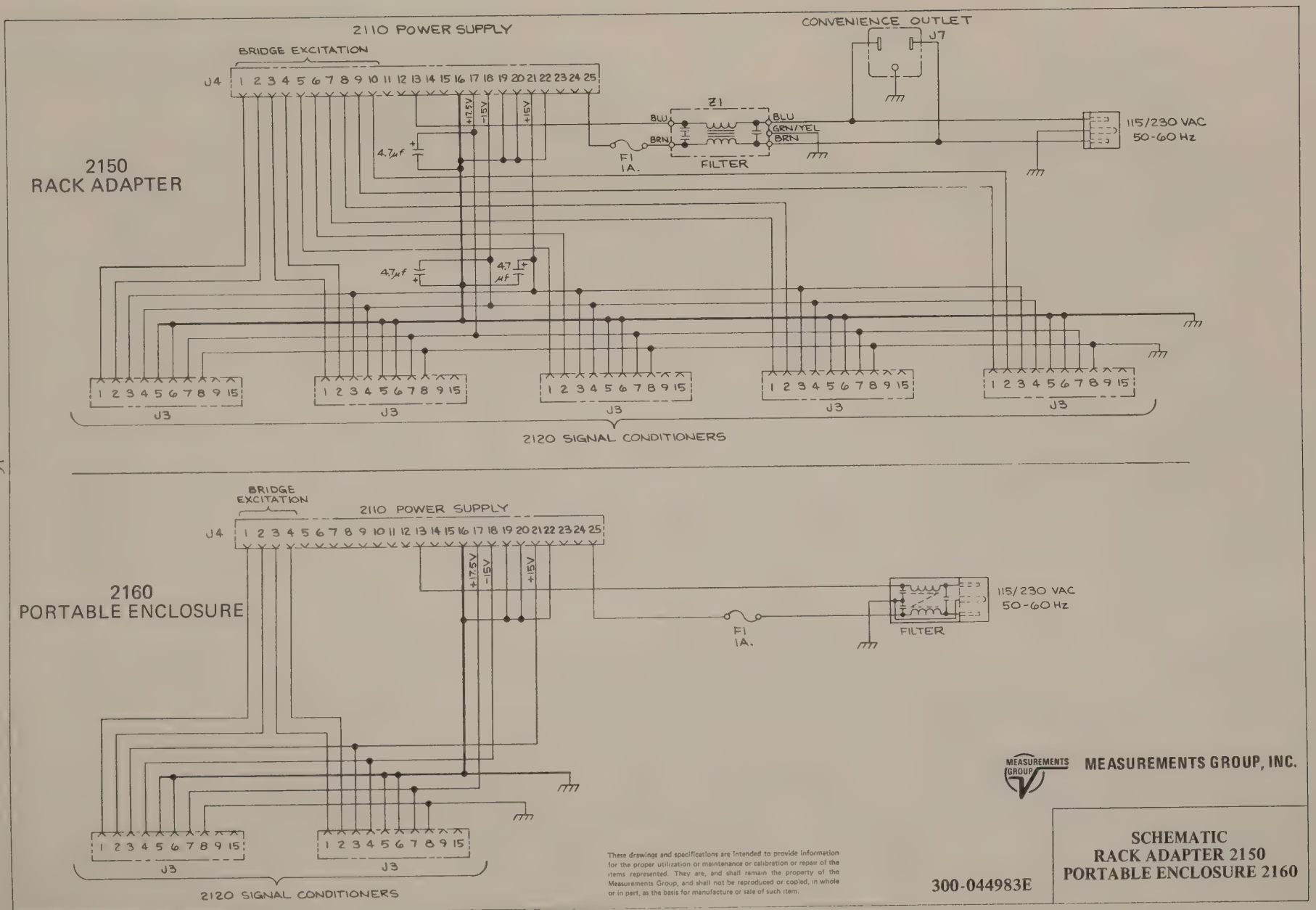
NOTE:

1. ALL J NO'S IN PARENTHESIS ( ) REPRESENT LEFT SIDE CIRCUIT.

400-052631Q

SCHEMATIC
SIGNAL CONDITIONER
2120



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300-044983E

SCHEMATIC
RACK ADAPTER 2150
PORTABLE ENCLOSURE 2160

APPENDIX

MODEL 2130 DIGITAL READOUT AND MODEL 2131 PEAK READING DIGITAL READOUT

GENERAL

The 2130 module provides an LED digital display plus a channel selector in a 2100 System-compatible package. The 2131 also includes peak reading capability. These units simply slide into either the 2150 Rack Adapter or the 2160 Enclosure. An additional line connection is *not* required as power is derived from the 2110 Power Supply through the rack adapter or enclosure. Standard cables (two supplied) make the necessary signal connection between the 2130/2131 and each of the 2120 Strain Gage Conditioner channels to be used in the display mode. The 2130/2131 will accept and switch up to 10 inputs. Additionally, front panel jacks are provided for utility inputs such as measuring bridge excitation via the 2110 EXTERNAL METER jacks. The front panel EXTERNAL input is single sided on the 2130 and differential on the 2131. An external monitoring device, such as an oscilloscope, can also be connected to the rear panel output connector to give simultaneous indications for a given selected input.

SPECIFICATIONS

All specifications nominal or typical at +23°C unless noted.

2130/2131 COMMON SPECIFICATIONS

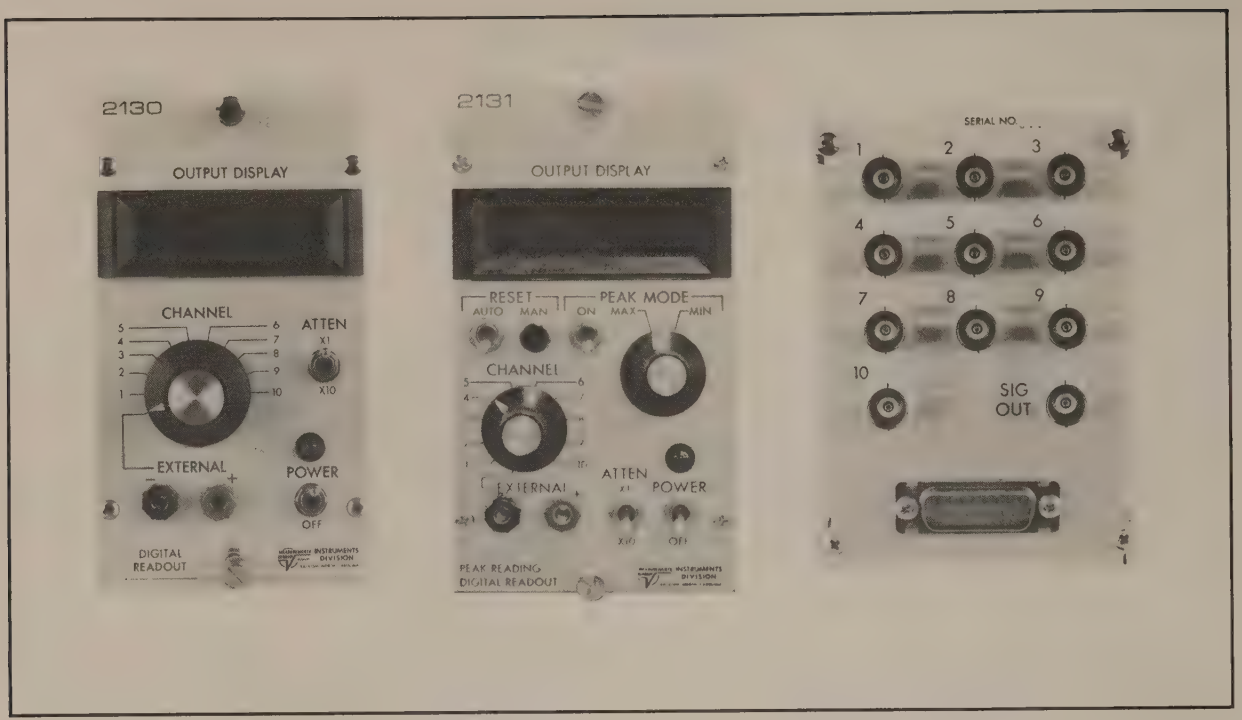
INPUT CAPACITY	10 Channels, BNC (Rear Panel) 1 Channel, Banana Jacks (Front Panel)
SWITCHED OUTPUT	Not attenuated, BNC (Rear Panel)
ATTENUATOR ACCURACY	±0.1% or better
UPDATE RATE	3 Readings/second, nominal
DIGITAL DISPLAY	3-1/2 Digit LED, ±1999 counts
DISPLAY HEIGHT	0.3 in *(7.6 mm)*
POWER	2110 Power Supply
SIZE & WEIGHT	5.25 H x 2.94 W x 10.97 in D *(133 x 75 x 279 mm)* 2 lb *(0.8 kg)*

2130 SPECIFICATIONS

INPUT VOLTAGE RANGE	±1999 mV (X1 range) ±19990 mV (X10 range)
INPUT IMPEDANCE	100 KΩ
ACCURACY	±(0.05% Reading +0.05% Full Scale) or better
COMMON MODE COMPLIANCE	±100 mV (rear panel input) minimum

2131 SPECIFICATIONS

INPUT VOLTAGE RANGE	±1999 mV (X1 range) ±10V (X10 range)
INPUT IMPEDANCE	Greater than 1 MΩ
COMMON MODE INPUT RANGE	±10V (rear panel input)
ACCURACY	
Step Input:	±0.1% ±5 counts for step input of greater than 10 milliseconds duration.
Repetitive Step Input:	±0.2% ±5 counts for repetitive step inputs of greater than 500 microsecond duration. Number of steps required $\geqslant \frac{\text{10 milliseconds}}{\text{Pulse Duration}}$
Repetitive Sine Wave Input:	±5.0% ±5 counts for repetitive sine wave of frequency less than 1000 Hz. ±1.0% ±5 counts for repetitive sine wave input of frequency less than 200 Hz.
STORAGE STABILITY	±3 counts/ minute maximum at +75°F *(+23°C)*
PEAK MODES	MAX (usually positive) excursion and MIN (usually negative) excursion.
PEAK RESET	Manual or Automatic



CONTROLS

OUTPUT DISPLAY — Provides a digital reading of the input as selected by CHANNEL selector. Typically used to monitor strain or bridge voltage.

CHANNEL Selector — Positions 1 to 10 select the input channel for display. (Generally position 1 is channel farthest to the left in rack, etc.)

The EXTERNAL position selects the input that is connected to the adjacent front panel jacks.

EXTERNAL Jacks — Provide ability to accept a front panel input, typically bridge voltage from 2110 EXTERNAL METER jacks.

ATTEN Switch — X1 position gives ±2 volt range. X10 position gives ±20 volt range (±10V for 2131).

POWER Switch — This switches the 17.5 Vdc power supply. The pilot lamp LED indicates when power is on.

SIG OUT (Rear Panel) — BNC Receptacle used to monitor the input signal on an external indicating instrument such as an oscilloscope. The desired channel is selected with the front panel CHANNEL selector switch.

Input Connectors (Rear Panel) — 10 BNC receptacles (typically connected to 2120 OUTPUT receptacles).

RESET Switches (2131) — AUTO (Toggle Switch) – When set to AUTO, the stored peak reading is periodically reset to the existing input level. Automatic reset will occur approximately every 5 to 10 seconds.

MAN (Push-button Switch) – When pressed, resets peak reading to the existing input level; the button should be held 1 second or more for a complete reset.

PEAK MODE Switches (2131) — ON–Display reads the stored peak reading. When off (down), display reads the existing input level.

MAX–The most positive (algebraic) input is stored.

MIN–The most negative (algebraic) input is stored.

SETUP

Install the 2130/2131 into the rack or enclosure as discussed in Section 2; the 2130/2131 is installed in exactly the same manner as the 2120 Conditioners filling one of the rack or enclosure slots.

INPUT CONNECTIONS

Connect the OUTPUT connector of each 2120 channel to be displayed to the appropriate 2130/2131 input, preferably using the standard cables, two of which are provided (Measurements Group No. 200-130827, accessory 2130-A27). If necessary, a cable can be made as discussed in Paragraphs 2.14 and 2.15; connect the 2120 OUTPUT (pin 3) to the center BNC pin and the shield (pin 2) to the BNC shell.

If desired, bridge voltage can be displayed by connecting banana plug jumpers between the 2110 EXTERNAL METER jacks and the 2130/2131 EXTERNAL jacks (connect red to red and black to black).

OPERATION

To prevent damage to small gages or sensitive galvanometers, before turning on power to the 2110 and 2130/2131, complete all steps in Section 2 through Paragraph 2.22.

Turn POWER on to both the 2110 and 2130/2131. Set the 2131 PEAK MODE and RESET-AUTO switches to off. Continue on Paragraph 2.23 utilizing the CHANNEL selector to choose the desired channel for display. Observe the OUTPUT DISPLAY when adjusting the 2120 balance and gain controls as well as when taking data. For convenience, the OUTPUT DISPLAY may be set up to read directly in engineering units.

The ATTEN switch is normally used in the X1 position but the X10 position is required when the reading goes over 1999 counts and the display flashes (indicating overrange). In the X1 mode, the 2130/2131 reads directly in millivolts (tens of millivolts in the X10 mode).

To use the 2131 without utilizing the peak reading feature, keep the PEAK MODE and RESET toggle switches set to the off (down) position. To take peak readings using the 2131, achieve desired calibration as discussed in the above paragraphs and proceed as follows depending upon type of input signal:

NON-RECURRING PEAKS

- Set RESET-AUTO to off (down position)
- Set PEAK MODE rotary switch to MAX and the toggle switch to ON
- Press RESET-MAN firmly (approximately 1 second)
- Load specimen or structure through the peak value of interest
- Read OUTPUT DISPLAY

If the MIN peak is of interest, turn PEAK MODE to MIN and press RESET-MAN again.

NOTES

In both MAX and MIN modes, a peak reading can have either a positive or negative sign. For example, if RESET results in a +1500 count reading (static load offset), a −440 count input excursion from the offset level will result in a reading of +1060 in the MIN mode or an unchanged reading of +1500 in the MAX mode. If instead the excursion were +200, the reading would have been an unchanged +1500 in the MIN mode or +1700 in the MAX mode.

A very slow display change can be due to peak storage drift that is not necessarily due to change in the strain amplitude. Typically the MAX peak storage can drift in either direction, whereas MIN peak storage tends to drift in the positive direction.

In the presence of 50/60 Hz pickup, the display will read slightly higher in peak reading mode because the pickup appears to the 2131 as a normal (although small) dynamic signal. Therefore, this pickup should be minimized by using twisted and shielded strain gage input wiring.

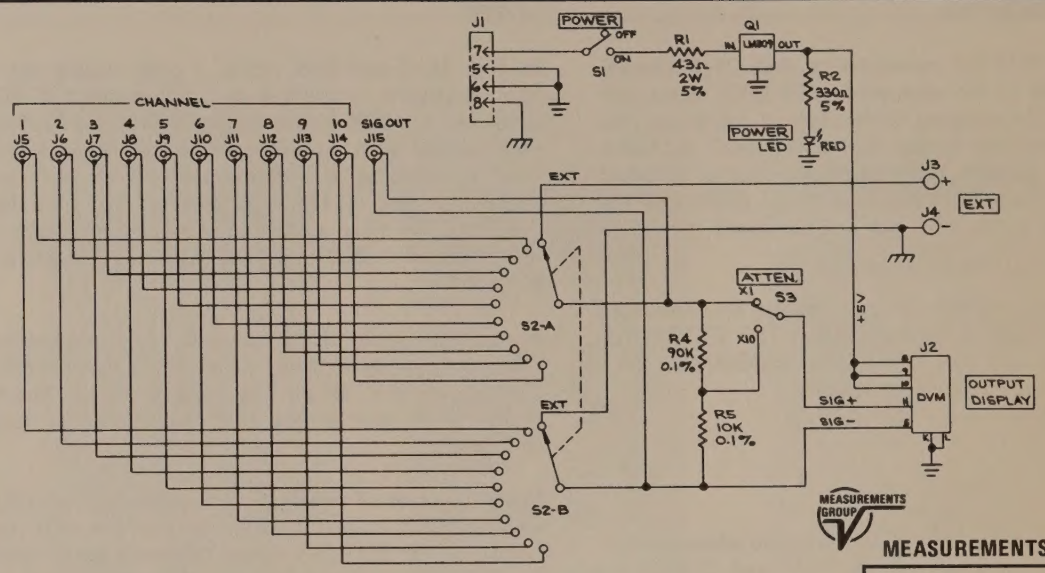
RECURRING PEAKS

- Set PEAK MODE toggle switch to off (down position)
- Establish static load (if required) and cyclic load
- Set PEAK MODE to ON
- Switch RESET to AUTO
- Press RESET-MAN firmly (approximately 1 second) or wait for automatic reset to reset display
- MAX or MIN should now be displayed according to the position of the PEAK MODE control
- To read the opposite peak, set PEAK MODE rotary switch accordingly and repeat prior two steps
- To determine the peak-to-peak amplitude, algebraically subtract the MIN reading from the MAX reading
- A decreased cyclic strain amplitude will be reflected in the display after reset occurs

SERVICE

A schematic of the 2130 and the 2131 can be found on the next page. Replacement parts can be obtained from the factory.

There is an internal adjustment in the 2130/2131 for span sensitivity. This can be trimmed by applying exactly ±1.900V to the input and adjusting the potentiometer at rear of meter until readout displays ±1900. A five-minute warm-up is recommended.



MEASUREMENTS GROUP, INC.

SCHEMATIC
2130 DIGITAL READOUT

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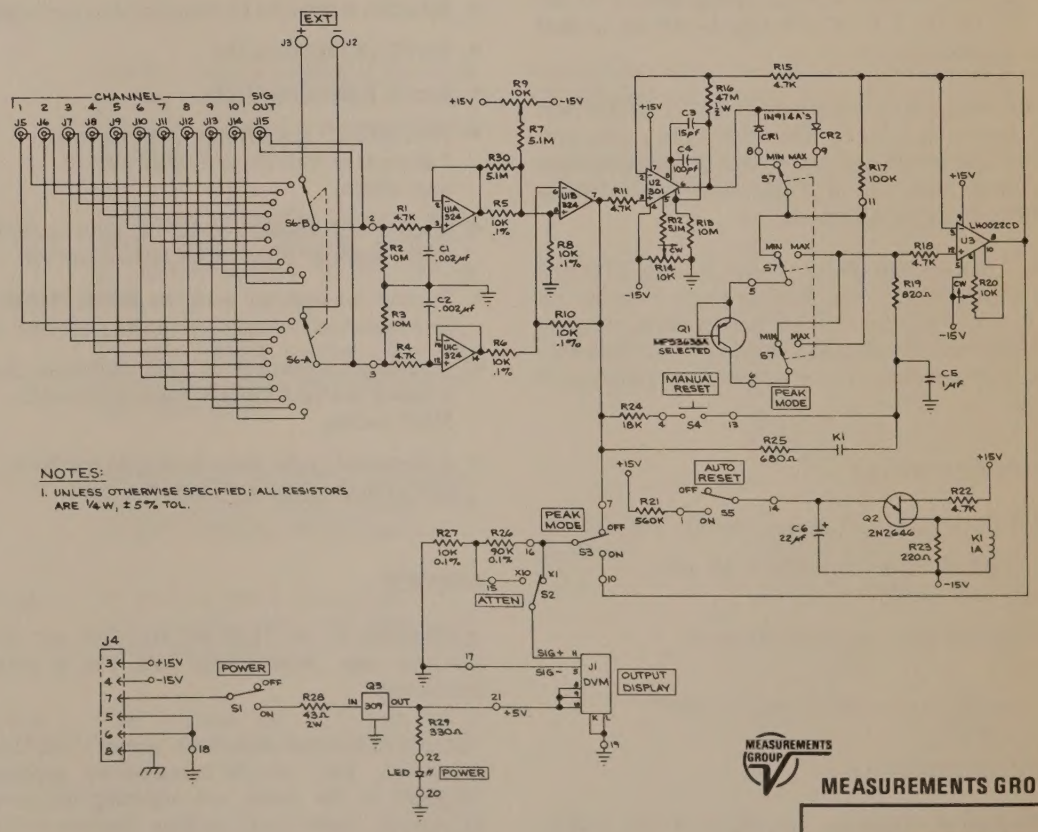

NOTES:
1. UNLESS OTHERWISE SPECIFIED; ALL RESISTORS ARE ¼W, ±5% TOL.

MEASUREMENTS GROUP, INC.

SCHEMATIC
2131 PEAK READING
DIGITAL READOUT

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